Short Research Article

Effects of Drying Procedureson the Nutritional, Biochemical and PhytochemicalCompositions of *Cola nitida*seeds

ABSTRACT

The effects of drying methods on the proximate compositions and phytochemical constituents of *Cola nitida* seeds were investigated by exposing the kola nuts to different drying procedures. The fresh *C. nitida* seeds were sorted and divided into four portions with each portion subjected to air-drying (AID), solar drying (SOD), oven-drying (OVD) and sun-drying (SUD) respectively. The results obtained markedly revealed that the proximate property of *C. nitida* seedsvaries from onedrying method to the other with OVD retaining the highest moisture and fat contentsbut has the least ash contents. On the other hand, air-dried *C. nitida* samples with the maximum carbohydrate level had the lowest fat, protein and fiber contents. The protein and ash contents of the sun-dried samples were the highest while SOD showed the least moisture and peak fiber contents respectively.Furthermore, it was observed that the phytochemical composition of *C. nitida* seeds on exposure to these drying procedures differs with the drying methods. Apparently, the air-dried *nitida* samples have the highest level of total phenols, tannins, alkaloidswithgood amounts of saponins. However, solar-dried *C. nitida* seeds which are rich in alkaloids have the least tannins, phenols and saponinscomposition.The trend of result from this present study revealed that the different drying methods employed in the post-harvest processing of *Cola nitida* seeds markedly affect thenutrient retention and bioactive constituents of kolanut.

Key words: Kola nuts, *Cola nitida*, drying, proximate, phytochemical constituents, antioxidants, minerals

INTRODUCTION

Kola nut, a major caffeine-containing nut belongs to the plant family Sterculiaceae with about 125 species of trees native to the tropical rainforests of Africa. However, the most common of these species in Nigeria are *Cola nitida*(gbanja) and *Cola acuminata*(abata) [1]. Aside the nuts' high caffeine contents, the fruit is reportedly known to contain other useful constituents such as theobromine, sugars, essential oils, alkaloids and many others [2]. Over time, the bioactive constituents, phytochemicals and antioxidant properties of kola nuts have been of keen interest to researchers in food and pharmaceutical industries. This owes to the fact that these components and properties are actively responsible for the medicinal importance of the nuts. Incidentally, kola nutsare known for their stimulatory effects and are employed in folkloric medicine for the treatments of diseases such as asthma, whooping coughs, rheumatism, parasitic infections, diabetes, low libido among others [1][3][4].

Kola nuts can be consumed or used in fresh or dried form. Fresh kola nuts are often consumed as a masticatory[5]while dried kola nuts are mostly used in the production of kola nut powder and beverages. Notably, drying of kola nut is one of the post-harvest processing methods of kola nuts. Drying, a major unit operation in kola processing aids the handling and preservation of the nuts by reducing its moisture content thus preventing deterioration by microorganisms and enzymes activities [6]. Although, several food processing methods including drying have been reportedly revealed to alter some nutritional, chemical, and phytochemical properties of foods, fruits and nutsconsequently causing a desirable or non-desirable change [7][8][9]. Therefore, while drying kola nuts, it is pertinent to employ the best and safest drying method that will conserve the bioactive and phytochemical constituents of the nuts thus preserving their medicinal, nutritional and pharmaceutical properties. Despite the fact that drying is a key post-harvest processing and handling method of kola nuts, however, there is no information documented in literatures on its effect on the bioactive constituents of the *C*. *nitida*. Hence, this present study subjected *C. nitida* seeds to different drying procedures and the influence of these drying methods on the proximate compositions and phytochemical properties of the seeds were investigated.

MATERIALS AND METHODS

Sample collection and preparation

Fresh*Cola nitida*seeds were purchased from Oke Otin farm, Okuku village, Odo Otin L.G.A, Osun State, Nigeria. The *Cola nitida* samples were sorted, divided into four portions and subjected to different drying procedures.

Comment [h1]: Add reference

Kola nuts processing and drying

Cola nitida seeds were dried to a constant weight by four different drying methods: air-drying at room temperature (AID), solar-drying (SOD), oven-drying (OVD) and sun-drying (SUD). Air-drying of *Cola* seeds were done at room temperature in a dark and well-ventilated room for a period of two weeks. The solar-drying took place in a solar chamber for 7 days whileoven-drying of *Cola nitida* was done in a hot-air oven at 65°C for 48 hours, the sun-drying was carried out by exposing the nuts to sun light for three days. After drying, all the dried samples were milled into fine particles, put in air-tight bottles and stored for subsequent analyses.

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Estimation of Proximate Compositions

The moisture and total ash contents were determined gravimetrically according to the methods of AOAC,2000 [10].Total carbohydrates content was evaluated as described by Dubois and co-authors [11].The total protein content was determined according to the method described byDevani et al. [12] with slight modifications. The samples were previously digested using Kjeldahl method. Then, the resulting mineralisatewas treated with ammonia and acetyl acetone/formaldehyde reagentin order to determine the nitrogen content. The yellow complexes(3, 5-diacetyl-1, 4-dihydrolutidin) formed were showed a maximumabsorption at 412 nm. The protein content was calculated using conversionfactor of 6.25.The crude fat and fibre contents were determined accordingto AOAC (2005) method [13].The latter was evaluated by filtration method in which the sample defatted with acetone was sequentially boiled with 1.25% acid followed by 1.25% alkali after which the residue was then dried in the oven at 130^{o}C for 2hrs.

Determination of polyphenolic compounds

Total phenols: Total phenols were extracted using acidified methanol and quantified by the Folin-Ciocalteu reagent method. Using UV spectrophotometer, the absorbance was read at 765nm and expressed as tannic acid equivalents mgkg−1[14].

Total Tannins: Tannin content was determined spectrometrically by the method of Hargerman *et al*. (2012) using folin-coicalteu reagent. The sample's tannin content was calculated after measuring the absorbance at 725nm against the blank solution and the result was express as g/100g [15].

Alkaloids: Alkaloids was quantitatively determined according to the methodsof Harborne et al.[16] and Sheikh et al. [17]. The contents were extracted with 10% acetic acid. The extract was concentrated on a water bath to one-quarter of the original volume followed by addition of few drops of concentrated ammonium hydroxide until the precipitation was complete after filtration, the precipitates were washed with 20 cm^3 of 0.1 M of ammonium hydroxide and then filtered, the residue was dried in an oven and the percentage alkaloid is expressed mathematically.

Total saponin: The saponin content was determined using the spectrophotometric method described by [18]. The concentration of saponins was interpolated from a standard curve of different concentrations of saponin standard in 80% aqueous methanol and expressed as g/100 g−1.

Mineral Analysis

The samples were ashed in a muffle furnace at 550 ^{0}C and the resulting ash was dissolved in hydrochloric acid. After filtration and appropriate dilutions, the concentrations of the trace elements; potassium (K), sodium (Na), iron (Fe) and zinc (Zn)were determined by an atomic absorption spectrophotometer (AAS) [19]**.**For phosphorus (P), the concentration was detected by spectrophotometric method of Ranganna (2005) with slight modification [20]

Antioxidant Activity

Antioxidant activity was determined using DPPH assay [21]. The utilization of DPPH method delivers an easy and rapid mode to estimate antioxidant activity against free radicals. 100 µl of the sample extractedwas mixed with 3.9 ml of 0.1 mM DPPHmethanolic solution. The vortex-mixedmixture was kept in the dark for 30 min. The absorbance was measured at λ=517 nm on a UV-VIS spectrophotometeragainst a blank of methanol without DPPH.The antioxidant activity (AA%) was expressedas percentage of inhibition of theDPPH radical.

Statistical Analysis

All assays were repeated thrice after which the mean and standard variations for various parameters were calculated. Statistical analyses were performed using Microsoft Excel Statistical Software, 2016. Differences between the means of the proximate, phytochemicals and mineral constituents' results, were tested using analysis of variance (ANOVA) at the significance level of $p < 0.05$.

Results and Discussion

The proximate compositions of *Colanitida* seeds after exposure to the four different drying procedures are presented in Table 1. Proximate analysis of food samples is used to assess the nutritional values of foods and this includes moistures, ash, fat, proteins and carbohydrate (CHO) contents [22]. The moisture contents of food and nuts provide an atmosphere that aids the growth and propagation of microorganism thus increasing food spoilage. Incidentally, foods that will have a long shelf life must have reduced moisture content. The moisture content of the *C. nitida* samples significantly varied in respect to drying methods with solar-dried sample retaining the lowest moisture content at 7.0125 ± 0.125, while the oven-dried *cola nitida* retained the highest moisture value at 9.175 ± 0.25, invariably, the solar-dried samples will have the longest shelf life. Similarly, the solar-dried sample which was with the lowest moisture content has the highest fiber content at 3.62 ± 0.02, followed by oven-dried (2.36 ± 0.08), sun-dried (2.1 ±

0.03)while air-dried sampleshave the least fiber content of 1.8 ± 0.05. A marked reduction in protein content was seen in air-dried (8.01 ± 0.125) samples, while no significant difference was seen in the protein values of oven-dried (8.70 ± 0.04) and solar-dried (8.80 ± 0.16) samples, sun-dried *C.nitida* seeds have the highest protein content (9.68±0.02). The decreased level of proteins observed in oven-dried samples correlates with the report of Devi [23] and this could be ascribed to the ability of the oven to accumulate energy which could in turn cause some protein denaturation in the samples [24]. Also, the reduced protein content in air-dried *C. nitida* samples could be due to enzymatic degradation resulting from lengthy period of drying at room temperature. There is no marked difference in the ash contents of *C. nitida seeds exposed to*the different drying methods except for oven-drying which have the least ash value (2.54±0.08).A remarkable difference was observed in the crude fat and carbohydrate (CHO) contents on exposure to the drying methods with oven-drying (0.9±0.13) and air-drying (77.94±0.08)methods having the highest fat and CHO values respectively. Presumably, this trend of results revealed that the proximate compositions of *C.nitida*seeds vary with different drying methods.

The fore-knowledge that biologically active plant compounds are quite unstable under elevated temperatures drew attention to the phytochemical compositions of the samples subjected to the different drying procedures.The result in Table 2 revealed the effect of the four drying methods; SOD, AID, SUD and OVD on the bioactive constituents of the *C. nitida* samples, in particular, alkaloids, tannins, phenols and saponins. These phytochemicals which are natural antioxidants are natural disease preventing, health promoting and anti-ageing substances [25]. Apparently from the result, *C. nitida*seeds that underwent air-drying have the highest contents of tannins (124.85±0.82) and phenols (151.11±1.02) followed by sun drying, oven drying. Solar drying significantly has the least tannins (37.42±0.65) and phenol (64.20±0.89) contents. In the same vein, the highest value of alkaloids was also observed in the air-dried (3.15±0.02)*C. nitida* samples although, this was followed by SOD (2.93±0.01), SUD (2.59±0.01) and OVD (1.75±0.01) has the least alkaloid content. Notably, this observation is in accordance with the report of Irondi *et al*. [26] who observed that air-drying of *Carica papaya* seeds preserved the total phenols and tannins constituents better than sun drying and oven drying. The reduction in the levels of tannins and phenols by SUD and OVD could be attributed to oxidation of these bioactive compounds by high temperatures according to the reports of Yoshioka and co-authors [27]. For the saponins, SUD was with the highest saponin contents (23.60±0.04), followed by SOD and OVD, AID has the lowest saponins.

The result presented in Table 3 described the influence of the four different drying procedures on the mineral composition of *Cola nitida* seeds.The minerals which include potassium (K), sodium (Na), iron (Fe), phosphorus (P) and zinc (Zn) are some of the minerals expected to be gotten on food consumption and they are needed for proper growth and physiological well-being of the body. These elements influence several biochemical processes in human organisms thereby making them medically of great importance [28]. Herein,the macro (phosphorus, potassium) and micro (sodium, iron, zinc) mineral contents ofthe *C. nitida* samples as presented in Table 3 revealed that these mineral compositions vary with the different drying methods.Apparently, Na (161.6 ± 0.8), P (167.7 ± 0.7) and Zn (5.72 ± 0.01) contents were highest in sun-dried samples, this was followed by oven-dried samples, the solar-dried and air-dried samples has the least phosphorus and zinc contents respectively. While sodium has its peak value in sun-dried samples and lowest value in solar-dried samples, potassium, another body electrolyte like sodium responsible for the maintenance of blood volume and bodily fluids[29] is significantly higher in air drying, followed by solar drying and has the least in sun drying. On the other hand, Fe, a mineral vital to the proper functioning of the oxygen-carrying protein, hemoglobin, has no significant difference in the various drying processes although it has its peak value in the oven-dried samples.

Figure 1 shows the effect of the four different drying methods on the antioxidant activities of the *C. nitida* seed sample. The DPPH radical scavenging ability of the samples was significantly higher in oven-dried (34.70±0.65) samples, followed by air-dried (31.44±0.83) and sun-dried samples (29.81±0.8), solar-

dried(25.63±0.59) *nitida* samples has the least DPPH radical scavenging ability. Incidentally, OVD and SOD showed the strongestand weakest antioxidant potentialsrespectively. This result is similar to that of Kolla et al. [30] which showed that oven-dried samples have the highest DPPH radical-scavenging ability than other drying methods. Also, the high antioxidant potential observed in the air-dried samples could be partly ascribed to the high level of phytochemicals and polyphenols observed in the air-dried *C*. *nitida* samples presented in Table 2.

Table 1: Effect of drying methods on Proximate Composition of *Cola nitida* seeds

(%)	AID	SOD	SUD	OVD
Moisture	8.8 ± 0.18	7.01 ± 0.125	8.29 ± 0.125	9.18 ± 0.25
Fat	0.59 ± 0.04	0.64 ± 0.08	0.76 ± 0.08	0.9 ± 0.13
Protein	8.01 ± 0.125	8.80 ± 0.16	9.68 ± 0.02	8.70 ± 0.04
Fiber	1.8 ± 0.05	3.62 ± 0.02	2.1 ± 0.03	2.36 ± 0.08
Ash	2.83 ± 0.16	2.89 ± 0.25	2.91 ± 0.08	2.54 ± 0.08
CHO	77.94 ± 0.08	77.02 ± 0.12	76.27 ± 0.10	76.35 ± 0.82

Values are means ± standard deviation of three replicates (n =3).
AID – Air drying; SOD – Solar drying; SUD – Sun drying; OVD – Oven drying.

Table 2: Effect of drying methods on the Phytochemical Compositions of *Cola nitida* seeds

	AID	SOD	SUD	OVD
Alkaloids (%)	3.15±0.02	2.93±0.01	2.59±0.01	1.75±0.01
Tannins (gTAE/kg)	124.85±0.82	37.42±0.65	101.21±0.85	62.25±0.21
Phenols (g/kg)	151.11±1.02	64.20±0.89	150.94±0.81	101.11±0.86
Saponins (g/kg)	14.34±1.64	21.25±1.67	23.60±0.04	18.27±0.83

Values are means ± standard deviation of three replicates (n =3).
AID – Air drying; SOD – Solar drying; SUD – Sun drying; OVD – Oven drying.

Table 3: Effect of drying methods on Mineral Compositions of *Cola nitida* seeds

mg/100g	AID	SOD	SUD	OVD
Potassium	636.4 ±20.5	597.8 ± 26.2	313.2± 8.2	547.9 ± 16.0
Sodium	119.1 ± 0.1	109.7 ± 0.8	161.6 ± 0.8	113.6 ± 0.8
Iron	1.76 ± 0.01	1.93 ± 0.01	1.56 ± 0.05	1.94 ± 0.01
Phosphorus	95.9 ± 0.06	93.4 ± 0.7	167.7 ± 0.7	112.8 ± 0.8
Zinc	0.96 ± 0.09	1.25 ± 0.02	5.72 ± 0.01	1.30 ± 0.01

Values are means ± standard deviation of three replicates (n =3).
AID – Air drying; SOD – Solar drying; SUD – Sun drying; OVD – Oven drying.

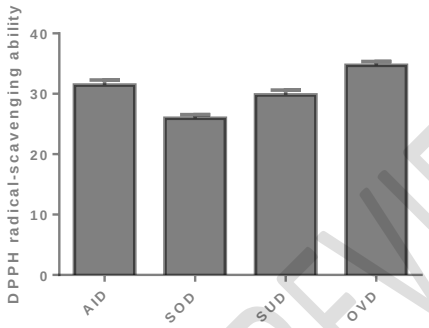

Figure 1. Effect of four different drying methods on the Antioxidant Activity of *Cola nitida* seeds
Values are means ± standard deviation of three replicates (n =3).
AID – Air drying SOD – Solar drying SUD – Sun dryingOVD – Oven drying

Conclusion

The different drying methods considered in this study influenced both the proximate and phytochemical compositions of *Cola nitida* seeds. General trend of results in proximate analysis showed that better nutrient retention was found in solar and sun-dried *C. nitida* than in the air- and oven-dried nuts. Hence, either solar drying or sun drying can be opted for as processing methods when proximate composition is under consideration. However, the analysis of phytochemicals apparently revealed that air-drying efficiently preserved the bioactive components that is phenols, tannins and alkaloids of *C. nitida* seeds therefore for effective preservation of these bioactive constituents, air-drying method of drying *Cola nitida* seeds may be most preferred.

Comment [h3]: Very simple conclusion. Rewrite with application of study too.

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